BROWDY AND NEIMARK, P.L.L.C.
ATTORNEYS AT LAW
PATENT AND TRADEMARK CAUSES
SUITE 300
624 NINTH STREET, N W
WASHINGTON, D C 20001-5303
TELEPHONE (202)-628-5197

ALVIN BROWDY (1917-1998)
SHERIDAN NEIMARK
ROGER L. BROWDY

ANNE M KORNBAU
NORMAN J LATKER
ROBERT M DEWITTY*
(*MD BAR ONLY)

OF COUNSEL
IVER P COOPER
JAY M FINKELSTEIN

TELECOPIER FACSIMILE
(202) 737-3528
(202) 393-1012

E MAIL
mail@browdyneimark com

PATENT AGENT
ALLEN C YUN, PH D

10/26/00 JC685 U.S. PTO

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Hon. Commissioner for Patents
Box Patent Appln
Washington, D.C. 20231

Re: New Patent Application in U.S.
Applicant: T. HAYASHI et al.
Title: ELECTROMAGNETIC WAVE ABSORBER
Atty's Docket: HAYASHI6

Sir:

Attached herewith is the above-identified application for Letters Patent including:

[X] Specification (17 pages), claims (2 page) and abstract (1 page)
[X] 12 Sheet Drawings (Figures 1-12B)
  [X] Formal [ ] Informal
[X] Declaration and Power of Attorney (2 pages)
  [X] Newly executed [ ]Copy from prior application no. ___
[ ] Preliminary Amendment
  [ ] Computer-readable Sequence Listing
[ ] Supplemental Preliminary Amendment adding new claims -
[ ] Information Disclosure Statement with 1449 and references
[ ] Applicant claims small entity status. See 37 CFR 1.27.
[X] Please charge my American Express Account, Form PTO-2038 attached in the amount of $ 710.00 to cover:
  [X] The filing fee calculated as follows (including any preliminary amendment for entry prior to calculation of the filing fee):

CLAIMS AS FILED				
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TOTAL CLAIMS	8 - 20	= 0	x 18	--0
INDEPENDENT CLAIMS	1 - 3	= 0	x 80	--0
[ ] Multiple Dependent Claim Presented			+ 270	--
[ ]Reduction of 1/2 for Small Entity				$
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The following statements are applicable:

[X] The benefit under 35 USC §119 is claimed of the filing date of: Application No. 11-307200 in Japan on 28 October 1999. A certified copy of said priority document [ ] is attached [ ] was filed in progenitor case __________ on ______________.

[ ] The present application is a Continuation Divisional Continuation-in-part of prior claims the benefit of U.S. Provisional application no. , filed .

[ ] Incorporation By Reference. The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied herewith, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

[ ] A signed statement deleting inventor(s) named in the prior application is attached.

[ ] The prior application was assigned to: ____________________________

[ ] Amend the specification by inserting before the first line the sentence:
--This is a continuation/division/continuation-in-part claims the benefit of U.S. Provisional of copending parent application Serial No. , filed .--

[ ] Certain documents were previously cited or submitted to the Patent and Trademark Office in the following prior application __________, which is relied upon under 35 USC §120. Applicants identify these documents by attaching hereto a form PTO-1449 listing these documents, and request that they be considered and made of record in accordance with 37 CFR §1.98(d). Per Section 1.98(d), copies of these documents need not be filed in this application.

[ ] A verified statement claiming small entity status is enclosed in progenitor application no. , filed . Status is still proper and desired.

[ ] The undersigned attorney of record hereby revokes the powers of attorney of:

[ ] The undersigned attorney of record hereby appoints associate power of attorney, to prosecute this application and to transact all business in the Patent and Trademark Office in connection therewith to:

[X] The Commissioner is hereby authorized to charge payment of the following additional fees associated with this communication or credit any overpayments to Deposit Account No. 02-4035:
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- [X] Any patent application processing fees under 37 CFR §1.17.

[X] The Commissioner is hereby authorized to charge payment of the following fees, based on any paper filed during the pendency of this application or any CPA thereof, to effect any amendment, petition, or other action requested in said paper or credit any overpayments to Deposit Account No. 02-4035:
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- [ ] The issue fee set in 37 CFR §1.18 at or before mailing the Notice of Allowance, pursuant to 37 CFR §1.311(b).
- [X] Any filing fees under 37 CFR §1.16 for presentation of extra claims.
- [X] If a paper is untimely filed in this or any CPA thereof by Applicant(s), the Commissioner is hereby petitioned under 37 CFR. §1.136(a) for the minimum extension of time required to make said paper timely. In the event a petition for extension of time is made under the provisions of this paragraph, the Commissioner is hereby requested to charge any fee required under 37 CFR §1.17 to Deposit Account 02-4035.

[X] The Commissioner is hereby authorized to credit any overpayment of fees accompanying this paper to Deposit Account No. 02-4035.

Respectfully submitted,
BROWDY AND NEIMARK, P.L.L.C.

By: ______________________
Sheridan Neimark
Registration No. 20,520

SN:edg
F:\T\taka\hayashi6\pto\APPLNTRANSMITTAL.doc

ELECTROMAGNETIC WAVE ABSORBER

BACKGROUND OF THE INVENTION

The present invention relates to an electromagnetic wave absorber for use in an anechoic chamber, etc., particularly to a flame-retardant electromagnetic wave absorber that can be easily assembled.

Recently, there have been increasing cases where electromagnetic waves emitted from electronic devices as noise interfere operations of the devices themselves or other devices. In such circumstances, electronic devices manufacturers are demanded to guarantee that their products neither suffer errors by external electromagnetic waves nor emit such electromagnetic waves as to affect nearby devices. Thus, the electronic devices are required to have an electromagnetic compatibility (EMC) to meet the above demand. A chamber used for EMC evaluation is such that metal plates are attached to its outer surface to shield the external electromagnetic waves, and that electromagnetic wave absorbers are attached to its inner surface to prevent the electromagnetic waves from reflecting. Such a chamber is referred to as "anechoic chamber". The anechoic chambers are classified as a larger anechoic chamber for large products such as automobiles and large electronic devices, and a compact anechoic chamber for relatively small electronic devices, etc.

Ferrite tile absorbers and carbon absorbers formed in a pyramid or wedge shape have been well known as the electromagnetic wave absorbers for use in the anechoic chambers. These absorbers are often used in combination. Although the carbon absorbers are generally minimized, correspondingly to electromagnetic wave-absorbing properties thereof and the size of the anechoic chamber, the absorbers for use in the larger anechoic chamber are even 1.5 to 2 m in height.

A "full-type carbon absorber" and a "hollow-type carbon absorber" have been well known. The full-type carbon absorber is generally obtained by expanding and molding a resin such as urethane resin penetrated with carbon. The hollow-type carbon absorber is generally obtained by assembling or bending carbon mixture boards, usable for the purposes of reducing weight and cost, etc. However, it is remarkably troublesome to produce the carbon absorbers of 1.5 to 2 m in height. Further, a member used for supporting the absorbers or applying them to the anechoic chamber is limited because it cannot be made of electromagnetic wave-reflecting materials such as metals. In a case where the shorter, pyramid- or wedge-shaped carbon absorber having a small base area is applied to the anechoic chamber, etc., the number thereof per a predetermined area is increased. With respect to the hollow-type carbon absorber, its assembling steps are increased with the number to unavoidably increase costs.

With regard to the immunity test recently carried out in the anechoic chamber, the electromagnetic waves with a strong electrical field are radiated to the electromagnetic wave absorber. In general, the electromagnetic wave absorber is extremely heated in the test because electromagnetic energy of the electromagnetic waves is converted to thermal energy. Therefore, the electromagnetic wave absorber is required to have excellent heat resistance and flame retardance. This is also desirable from an architectural point of view, when the electromagnetic wave absorber is applied to the inner wall of the anechoic chamber. However, because most of the conventional carbon electromagnetic wave absorbers are made of carbon dispersed in resins, they are poor in flame retardance, often burning to generate a toxic combustion gas. Though a flame-resistant material may be added to the absorber to increase the flame

resistance, the material often causes aging degradation of the absorber for a long time.

To solve the problems mentioned above, carbon electromagnetic wave absorbers comprising inorganic materials such as ceramic fibers, calcium carbonate, cement mortar, etc. were developed. However, these absorbers newly cause problems such as high material cost, heavy weight, poor formability, etc.

OBJECT AND SUMMARY OF THE INVENTION

Accordingly, an objective of the present invention is to provide a flame-retardant electromagnetic wave absorber that exhibits excellent formability and electromagnetic wave-absorbing properties, and can be easily assembled and applied.

As a result of intense research in view of the above objective, the inventors have found that an electromagnetic wave absorber, which is produced by forming a wave-absorbing body in a pyramid shape by fitting (or engaging) a plurality of wave-absorbing plates into each other and disposing a base plate on the bottom thereof, exhibits excellent electromagnetic wave-absorbing properties, formability and flame retardance.

Thus, an electromagnetic wave absorber of the present invention comprises a wave-absorbing body and a base plate supporting the bottom thereof, wherein the wave-absorbing body is formed in a pyramid shape by fitting polygonal wave-absorbing plates into each other.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view showing an embodiment of a wave-absorbing plate used in the present invention;

Fig. 2 is a perspective view showing production of an electromagnetic wave absorber of EXAMPLE 1 according to the present invention, wherein (a) shows wave-absorbing plates before engaging, (b) shows a wave-absorbing body, an upper plate and a base plate, and (c) shows the resultant electromagnetic wave absorber;

Fig. 3 is a perspective view showing production of an electromagnetic wave absorber of EXAMPLE 2 according to the present invention;

Fig. 4 is a perspective view showing a plurality of electromagnetic wave absorbers according to the present invention connected to each other;

Fig. 5 is a perspective view showing production of an electromagnetic wave absorber of EXAMPLE 3 according to the present invention, wherein (a) shows wave-absorbing plates before fitting, and (b) shows the resultant electromagnetic wave absorber;

Fig. 6 is a perspective view showing production of an electromagnetic wave absorber of EXAMPLE 4 according to the present invention;

Fig. 7 is a perspective view showing production of an electromagnetic wave absorber of EXAMPLE 5 according to the present invention;

Fig. 8 is a perspective view showing production of an electromagnetic wave absorber of EXAMPLE 6 according to the present invention;

Fig. 9 is a perspective view showing production of an electromagnetic wave absorber of EXAMPLE 7 according to the present invention, wherein (a) shows wave-absorbing bodies before engaging and (b) shows the resultant electromagnetic wave absorber;

Fig. 10 is a perspective view showing production of an

electromagnetic wave absorber of EXAMPLE 8 according to the present invention;

Fig. 11 is a perspective view showing production of an electromagnetic wave absorber of EXAMPLE 9 according to the present invention; and

Fig. 12 is a perspective view showing production of an electromagnetic wave absorber of EXAMPLE 10 according to the present invention, wherein (a) shows wave-absorbing plates and an upper plate before fitting and (b) shows the resultant electromagnetic wave absorber.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

An electromagnetic wave absorber of the present invention comprises a wave-absorbing body and a base plate supporting the bottom thereof, wherein the wave-absorbing body is formed in a pyramid shape by fitting a plurality of wave-absorbing plates, each having a shape of a polygon such as a triangle and a trapezium, into each other. Disposed on the top of the wave-absorbing body may be an upper plate, if necessary. The wave-absorbing plate and the electromagnetic wave absorber according to the present invention will be described below.

[1] Wave-absorbing plate

The wave-absorbing plate used in the present invention is preferably composed of a couple of non-combustible boards and an electrically conductive layer sandwiched therebetween. Such a wave-absorbing plate may be prepared by, for example, coating the electrically conductive layer on one non-combustible board and mounting the other non-combustible board to the layer. As shown in Fig. 1, the wave-absorbing plate 20 may be prepared by sandwiching a carbon sheet 21 of a carbon-dispersed resin between the non-combustible boards 20a and 20b.

The wave-absorbing plate may be cut into a shape of a triangle, a quadrangle, a trapezium, a tapered polygon, etc. depending on its use, like the wave-absorbing plates 2, 2a, 5, 6, 7, 8 and 12 shown in Figs. 2 to 12. The non-combustible boards may be made of the same or different materials. It is preferable that the non-combustible board is mainly made of inorganic materials. The non-combustible board is more preferably made of a foamed material mainly composed of calcium carbonate. The electrically conductive layer is preferably an electrically conductive sheet made of carbon powder or fiber dispersed in a resin. The electrically conductive sheet is preferably prepared, for example, by mixing carbon powder and a polypropylene resin, and using conventional sheet-forming processes.

In the case of using the carbon sheet as the electrically conductive layer, the wave-absorbing plate can be easily and economically prepared by a usual molding and laminating method without complicated processes. Such a wave-absorbing plate can be easily engaged each other to form the wave-absorbing body described below. The wave reflection and absorption properties of the wave-absorbing plate depend on the carbon sheet, so that the properties and use conditions can be diversified by controlling the kind and/or amount of carbon.

According to a preferred embodiment of the present invention, the electrically conductive layer is made of a resin penetrated with carbon. The resin acts to eliminate the problems of moldability. The non-combustible board mainly composed of an inorganic material generally has a few binders, in particular, such that composed of an inorganic material having a large surface area and a small diameter, or a fibrous inorganic material is poor in moldability. In contrast, the wave-absorbing plate containing a resin can be easily formed by various forming methods with

little restriction, so that the plate can find wide application.

[2] Electromagnetic wave absorber

The wave-absorbing body used for the electromagnetic wave absorber of the present invention may be formed by fitting (or engaging) and adhering polygonal wave-absorbing plates to each other without particular tools. Therefore, the electromagnetic wave absorber can be easily assembled at a construction site. Although the conventional, hollow, pyramid-shaped, electromagnetic wave absorber is generally formed of four wave-absorbing plates, the wave-absorbing body used in the present invention is basically formed of only two wave-absorbing plates as exemplified in Fig. 2, remarkably reducing the number of assembling steps. The wave-absorbing plate used in the present invention may be piled up, so that it can be more efficiently transported and carried to a construction site than the conventional plates assembled in a pyramid shape beforehand.

As shown in Fig. 2 (a), the wave-absorbing body 1 may be formed by fitting a polygonal wave-absorbing plate 2 having a notch in an upper portion to a polygonal wave-absorbing plate 2 having a notch in a lower portion through their notches in a crossing manner. Instead, the wave-absorbing body may be formed as shown in Fig. 3 by fitting wave-absorbing plates 2a into fitting-apertures 12 in the wave-absorbing plate 2.

In a case where the wave-absorbing body is formed by fitting two wave-absorbing plates to make them intersect, the direction of intersection is not particularly limited and may be changed corresponding to the desired properties. The wave-absorbing body may be formed of three or more wave-absorbing plates while changing the shape of the notches, the apertures, etc.

Disposed on the bottom of the wave-absorbing body is a base plate, with an upper plate disposed on the top thereof if necessary. These plates

are preferably disposed by fitting to be easily assembled. The upper plate and the base plate are preferably composed of materials that reflect few electromagnetic waves. The materials may be the same as those for the wave-absorbing plate. As shown in Fig. 2 (b), it is preferred that the upper plate 3 and the base plate 4 have a fitting-shape such as a groove 15 and an opening 16 to be easily fitted with the top or bottom of the wave-absorbing body 1.

As shown in Fig. 4, a plurality of the electromagnetic wave absorbers may be connected to each other by providing a convex portion 13a and a concave portion 13b on both sides of the base plate 4, and fitting the convex portion 13a of one base plate 4 into the concave portion 13b of the other base plate 4. The electromagnetic wave absorber of the present invention may be attached to a wall or a ceiling by fixing the base plate thereon beforehand and by assembling the wave-absorbing plates, the upper plate, etc. with the base plate. Another base plate having a convex portion and a concave portion may be disposed on the rear surface of the general, square-shaped base plate to be continuously connected.

Although the wave-absorbing body is formed in a pyramid shape basically, various wave-absorbing bodies having suitably changeable apparent density, which is determined by a solid part and space in the wave-absorbing bodies, may be formed by controlling combination, size, etc. of the wave-absorbing plates. For example, the wave-absorbing body may be in a shape of continuously connected, partially overlapping pyramids as shown in Fig. 5. This wave-absorbing body may be formed by engaging wave-absorbing plates 5, each being continuously connected, partially overlapping triangles in shape, each other in a lattice pattern. As shown in Fig. 7, the wave-absorbing body may be formed by radially fitting the trapezium-shaped, wave-absorbing plates 7 into the base plate 4

to change the apparent density thereof.

Further, as shown in Figs. 6 and 9, the electromagnetic wave absorber may further comprise a shorter wave-absorbing body formed of the wave-absorbing plates 6 or 5 each having notches 11 in addition to the wave-absorbing body 1. As shown in Figs. 8, 10 and 11, a wave-absorbing plate 8, a wedge-shaped, wave-absorbing body 9, a shorter pyramid-shaped, wave-absorbing body 10, etc. may be used in combination with the wave-absorbing body 1.

Furthermore, as shown in Fig. 12, with the wave-absorbing body 1 may be assembled a plurality of wave-absorbing plates 12 parallel to the base plate 4. The wave-absorbing plate 12 efficiently acts to change impedance correspondingly to the incident electromagnetic waves, thereby improving the electromagnetic wave absorption characteristics of the absorber. The number of the wave-absorbing plate 12 may be appropriately set depending on operating conditions and circumstances. Controlling the carbon-content of each wave-absorbing plates 12 enables to make them equal in size. A plate made of a material that reflects few electromagnetic waves may be assembled with the wave-absorbing body to improve the strength thereof.

The wave-absorbing body used in the present invention has a pyramid shape ideal for changing the apparent density, enabling match impedance to the incident electromagnetic waves. The apparent density is more preferably changed by appropriately selecting the shape or number of the wave-absorbing plates and/or the method for assembling the plates. Additionally, the electromagnetic wave absorber of the present invention may be used in combination with a ferrite tile. The ferrite tile is preferably mounted to the bottom surface of the base plate. The electromagnetic wave-absorbing properties of the electromagnetic wave

absorber may be matched to that of the ferrite tile absorber by appropriately selecting composition thereof. Thus, the electromagnetic wave-absorbing properties of the entire absorber can be improved in the wide frequency range.

The electromagnetic wave absorber of the present invention has a larger surface area than those of the conventional pyramid-shaped absorbers to show a high heat-dissipating efficiency and an excellent heat resistance, thereby preventing the temperature elevation of the absorber even when the electromagnetic waves with strong electric field are radiated.

The electromagnetic wave absorber according to the present invention will be described in detail below with reference to Figs. 2 to 11.

EXAMPLE 1

Carbon powder was mixed with a polypropylene resin, and the resultant mixture was shaped into a carbon sheet having a thickness of 1 mm. After an adhesive was applied to both surfaces of the carbon sheet, the carbon sheet was sandwiched between a couple of lightweight, non-combustible boards having a thickness of 10 mm. Immediately thereafter, the resultant laminate was pressed at 100 kg/cm^2 or less to prepare a non-combustible plate having a width of 900 mm, a length of 1800 mm and a thickness of 22 mm for use as a wave-absorbing plate. Incidentally, the lightweight, non-combustible board was made of a foamed material mainly composed of calcium carbonate.

Two non-combustible plates obtained above were cut into a trapezium-shape with an upper base of 100 mm, a lower base of 600 mm and a height of 1200 mm, and notches 11 having a width of 22.5 mm were provided in the upper base of one plate and the lower base of another plate,

to prepare wave-absorbing plates 2 shown in Fig. 2 (a). Then, the notches of the wave-absorbing plates 2 were engaged each other so that the wave-absorbing plates 2 are assembled in a cross shape, thereby forming a pyramid-shaped wave-absorbing body 1 shown in Fig. 2 (b). An upper plate 3 was disposed on the top of the wave-absorbing body 1, and a base plate 4 was disposed on the bottom thereof to obtain an electromagnetic wave absorber shown in Fig. 2 (c). The upper plate 3 and the base plate 4 were made of the lightweight, non-combustible board. The upper plate 3 and the base plate 4 had a cross-shaped opening 16 or a cross-shaped groove 15, and the wave-absorbing body 1 was inserted and fixed thereto. Incidentally, each part was adhered to one another by an adhesive, and the same is true in the following Examples.

EXAMPLE 2

The non-combustible plate prepared in EXAMPLE 1 was cut into two trapezium-shaped plates each having an upper base of 40 mm, a lower base of 300 mm and a height of 1200 mm. At the center of one trapezium-shaped plate were provided two fitting-apertures 12 and at the bottom thereof were provided two convex portions 13 to be inserted into openings 16 of the base plate 4, and the other trapezium-shaped plate was split in two and at the side and bottom thereof were provided convex portions 13, whereby wave-absorbing plates 2 and 2a shown in Fig. 3 were prepared. The convex portions 13 of the wave-absorbing plate 2a were fitted into the fitting-apertures 12 of the wave-absorbing plate 2, and an upper plate 3 and a base plate 4 were disposed on the resultant wave-absorbing body in the same manner as in EXAMPLE 1 to obtain an electromagnetic wave absorber. Incidentally, the upper plate 3 used in EXAMPLE 2 was in a cross-shape suitable for the shape of the top of the

wave-absorbing body.

In the structures in EXAMPLES 1 and 2, the wave-absorbing body having a pyramid shape, ideal for changing the apparent density to match impedance to the incident electromagnetic waves, can be easily formed by combining only two wave-absorbing plates. Thus, according to the present invention, the parts composing the absorber can be reduced without deterioration of the electromagnetic wave-absorbing properties to remarkably reduce production costs. Additionally, the electromagnetic wave absorber of the present invention can be easily applied even when its height is more than 1 m because most of the parts composing the absorber are lightweight plates, resulting in reducing construction costs. Further, the parts may be transported in a plate-shape because the electromagnetic wave absorber according to the present invention can be easily assembled at a construction site without particular tools, thereby reducing transporting costs.

EXAMPLE 3

Six wave-absorbing plates 5 shown in Fig. 5 (a), which were in a shape of continuously connected three triangles with a base of 200 mm and a height of 450 mm each having notches 11 with a width of 22.5 mm in the top or the center of the bottom, were prepared of the non-combustible plate obtained in EXAMPLE 1. The notches 11 of the wave-absorbing plates 5 were engaged each other, such that the wave-absorbing plates 5 are made integral in a lattice pattern. On the bottom of the resultant wave-absorbing body having a shape of continuously connected, partially overlapping pyramids was disposed a base plate 4 to obtain an electromagnetic wave absorber shown in Fig. 5 (b).

A plurality of absorbers are needed when a conventional

electromagnetic wave absorber with a small base area is applied to a predetermined area, thereby increasing production steps and costs. For example, in a case where a pyramid-shaped absorber is applied to an area of 60 cm around, only one absorber is needed when it has a base of 60 cm around, and nine absorbers are needed when it has a base of 20 cm around. In contrast, because the electromagnetic wave absorber according to EXAMPLE 3 has a structure where the pyramids are continuously connected, both the numbers of parts and assembling processes can be reduced. The electromagnetic wave absorber constituted by a plurality of units integrally connected to each other can be efficiently assembled to form a panel.

EXAMPLE 4

Four wave-absorbing plates 6 shown in Fig. 6, which were in a shape of triangle with a base of 300 mm and a height of 450 mm having a notch 11 with a width of 22.5 mm in the center of the base, were prepared of the non-combustible plate obtained in EXAMPLE 1. The wave-absorbing plates 6 and the wave-absorbing body 1 formed in the same manner as in EXAMPLE 1, which was provided notches 11 of 22.5 mm in width on each hypotenuse, were engaged each other through the notches, and a base plate 4 was disposed on the bottom thereof to obtain an electromagnetic wave absorber.

EXAMPLE 5

Four wave-absorbing plates 7 shown in Fig. 7, which were in a shape of a trapezium with an upper base of 40 mm, a lower base of 400 mm and a height of 1200 mm, were prepared of the non-combustible plate obtained in EXAMPLE 1. The wave-absorbing plates 7 were fitted into

the wave-absorbing body 1 formed in the same manner as in EXAMPLE 1, and a base plate 4 was disposed on the bottom thereof to obtain an electromagnetic wave absorber. On the base plate 4 were provided grooves 15 to which the wave-absorbing plates 7 could be fixed beforehand, so that they could be stably fitted with ease.

EXAMPLE 6

Four wave-absorbing plates 8 shown in Fig. 8, which were in a shape of a trapezium with an upper base of 200 mm, a lower base of 280 mm and a height of 400 mm having a side perpendicular to both bases, were prepared of the non-combustible wave-absorbing plate obtained in EXAMPLE 1. The wave-absorbing plates 8 were leaned on and fitted to the wave-absorbing body 1 formed in the same manner as in EXAMPLE 1, and a base plate 4 was disposed on the bottom of the wave-absorbing body 1 to obtain an electromagnetic wave absorber. On the wave-absorbing plates 2 and the base plate 4 were provided grooves 15 to which the wave-absorbing plates 8 could be fixed beforehand, so that they could be stably fitted with ease.

In EXAMPLES 4 to 6, the apparent density of the electromagnetic wave absorber increases as the number of the wave-absorbing plates increases to control impedance. This improves the electromagnetic wave-absorbing properties in a high frequency range.

EXAMPLE 7

Four wave-absorbing plates 5 shown in Fig. 9 (a) each having notches 11 were engaged each other to obtain a shorter wave-absorbing body, and a base plate 4 was disposed on the bottom thereof. On the base plate 4 were provided grooves (not shown) to be engaged with wave-

absorbing bodies beforehand. The wave-absorbing body 1 formed in the same manner as in EXAMPLE 1 was provided with 22.5-mm-wide notches 11, which were then engaged with the notches 11 of the shorter wave-absorbing body to obtain an electromagnetic wave absorber shown in Fig. 9 (b).

EXAMPLE 8

As shown in Fig. 10, a base plate 4 was disposed on the bottom of the wave-absorbing body 1 formed in the same manner as in EXAMPLE 1, and wedge-shaped, wave-absorbing bodies 9 were assembled with the base plate 4 to obtain an electromagnetic wave absorber. The wedge-shaped, wave-absorbing body 9 was formed by bending a polygonal, non-combustible wave-absorbing plate several times into a double wedge shape. Specifically, the wave-absorbing body 9 having a length of 300 mm and a width of 150 mm was in a tapered double wedge shape where each wedge had a base of 150 mm and a height of 300 mm. On the base plate 4 were provided grooves 15 to which the wave-absorbing body 1 and the wedge-shaped, wave-absorbing bodies 9 could be fixed beforehand, so that they could be stably fitted with ease.

EXAMPLE 9

As shown in Fig. 11, a base plate 4 was disposed on the bottom of the wave-absorbing body 1 formed in the same manner as in EXAMPLE 1, and shorter wave-absorbing bodies 10 were assembled with the base plate 4 to obtain an electromagnetic wave absorber. The shorter wave-absorbing body 10 was in a shape of continuously connected, partially overlapping nine pyramids, each pyramid having a base of 100 mm × 100 mm and a height of 300 mm. The wave-absorbing body 10 was prepared by

molding a foamed urethane resin penetrated with a carbon, and fixed to the base plate 4 by adhering. Although the wave-absorbing body 10 may be formed of the wave-absorbing plates, this suffers disadvantage that the number of forming processes is increased. Such a wave-absorbing body may have a wedge-shape, etc.

EXAMPLE 10

As shown in Fig. 12 (a), a base plate 4 was disposed on the bottom of the wave-absorbing body 1 formed in the same manner as in EXAMPLE 1, and wave-absorbing plates 12 with a thickness of 22 mm, each having a cross-shaped opening 16, were assembled with the wave-absorbing body 1 to be parallel to the base plate 4. The wave-absorbing plates 12 were 450 mm × 450 mm and 300 mm × 300 mm in size, respectively. Then, an upper plate 3, which was composed of a lightweight non-combustible board of 200 mm × 200 mm in size and had a cross-shaped opening 16 in the center, was fitted with the top of the wave-absorbing body 1 to obtain an electromagnetic wave absorber shown in Fig. 12 (b).

Each of the electromagnetic wave absorbers of EXAMPLES 7 to 10 comprises a shorter wave-absorbing body formed in a shape of a pyramid, a wedge or continuously connected, partially overlapping pyramids in addition to the wave-absorbing body 1 prepared in EXAMPLE 1. The electromagnetic wave-absorbing properties in a high frequency range are improved as well as the absorbers of EXAMPLES 4 to 6.

While the electromagnetic wave absorber according to the present invention has been described in detail, it is to be understood that the invention is not limited thereto, and may be otherwise embodied within the scope of the appended claims. For example, the wave-absorbing plate may be used in a shape of a tapered pentagon, etc., or above-mentioned

shorter wave-absorbing body may be conical.

As described in detail above, an electromagnetic wave absorber of the present invention comprises a wave-absorbing body formed by fitting (or engaging) a plurality of wave-absorbing plates each having a shape of a polygon such as a triangle, a trapezium, etc., and a base plate supporting the bottom thereof. The wave-absorbing body having a pyramid shape ideal for matching impedance to the incident electromagnetic waves can be formed without deterioration of the electromagnetic wave-absorbing properties. Further, according to the present invention, the number of the parts composing the absorber is reduced. Therefore, great reduction is achieved in production costs and the absorber can be easily assembled in construction site to reduce construction costs and transporting costs. Furthermore, by using the wave-absorbing plate composed of a couple of lightweight, non-combustible boards and an electrically conductive layer sandwiched therebetween, a flame retardant electromagnetic wave absorber can be obtained with ease.

WHAT IS CLAIMED IS:

1. An electromagnetic wave absorber comprising a wave-absorbing body and a base plate supporting the bottom of said wave-absorbing body, wherein said wave-absorbing body is formed in a pyramid shape by fitting polygonal wave-absorbing plates into each other.

2. The electromagnetic wave absorber according to claim 1, wherein said wave-absorbing body is formed by fitting a polygonal wave-absorbing plate having a notch in an upper portion and a polygonal wave-absorbing plate having a notch in a lower portion into each other through said notches in a crossing manner.

3. The electromagnetic wave absorber according to claim 1, wherein said wave-absorbing body is constituted by a plurality of first polygonal wave-absorbing plates each having a notch in an upper portion and a plurality of second polygonal wave-absorbing plates each having a notch in a lower portion, each plate being in a shape of continuously connected, partially overlapping polygons, said first polygonal wave-absorbing plates and said second polygonal wave-absorbing plates engaging each other through their notches in a lattice pattern, such that said wave-absorbing body has a shape of continuously connected, partially overlapping pyramids.

4. The electromagnetic wave absorber according to claim 1, further comprising a shorter wave-absorbing body formed in a shape of a pyramid, a wedge or continuously connected, partially overlapping pyramids.

5. The electromagnetic wave absorber according to claim 1, wherein the bottom surface of said base plate is provided with a ferrite tile.

6. The electromagnetic wave absorber according to claim 1, wherein said wave-absorbing plate is in a shape of a triangle, a trapezium or a tapered polygon.

7. The electromagnetic wave absorber according to claim 1, wherein said wave-absorbing plate is composed of a couple of non-combustible boards mainly made of an inorganic material and an electrically conductive layer sandwiched therebetween.

8. The electromagnetic wave absorber according to claim 7, wherein said electrically conductive layer is an electrically conductive sheet made of carbon powder or fiber dispersed in a resin.

ABSTRACT OF THE DISCLOSURE

The present invention provides a flame-retardant electromagnetic wave absorber that exhibits excellent formability and electromagnetic wave-absorbing properties, and can be easily assembled and constructed. The electromagnetic wave absorber comprises a wave-absorbing body and a base plate supporting the bottom thereof, wherein the wave-absorbing body is formed in a pyramid shape by fitting polygonal wave-absorbing plates into each other.

ELECTRICAL CONDUCTOR WITH RECTANGULAR OR SQUARE CROSS-SECTION

Background of the Invention

This application is based on and claims the benefit of German Patent Application No. 19951709.6 filed October 27, 1999, which is incorporated by reference herein.

The invention relates to an electrical conductor with a quadrilateral cross-section and having an electrically insulating layer on all sides of the conductor, and further comprising a topcoat lacquer film provided on the insulating layer, and further relates to a process for the production of an electrical conductor.

Electrically insulated conductors are known which are used for the production of coils for transformers. The electric insulation is applied in the form of a lacquer film to all sides of the conductor.

If these types of conductors are used as so-called twisted conductors, significant mechanical demands are made of the lacquer coating. Therefore, the insulation must be able to withstand the mechanical deformations and demands caused by the twisting, as well as the later winding and pressing within the transformer winding, without damage. Electrical subconductor short circuits are undesirable, as under certain circumstances they can reduce the degree of effectiveness.

Lacquers based on polyvinyl acetal (PVA) are suitable for this purpose, as these materials have very good oil and hydrolysis resistance properties.

The mechanical strength of the transformer winding can be further increased by coating the enameled single conductor with an additional topcoat lacquer. The

topcoat lacquer can be applied to conductor materials of any degree of strength. The layer thickness is between 0.040 and 0.080 mm.

After the winding and pressing, the twisted conductor is hardened in a drying process. The subconductors bake together under pressure at a temperature of 120-130°.

A compact conductor with a very high mechanical section modulus is obtained due to the internal adhesion of the single conductors. The transformer coils can thereby withstand strong electrodynamic forces.

The production process for these types of topcoated wires requires two separate lacquer ovens due to the kinetics of the hardening reactions, which typically vary, and two separate coating processes. In the usual procedure, the conductor, coated with the first lacquer film, is drawn through a topcoat lacquer, typically consisting of a binder dissolved in an organic solvent, and the amount of topcoat lacquer applied is delimited by sizing dies in order to produce a defined layer thickness. The enameled conductor is hereby coated with the topcoat lacquer on all sides (see, e.g., U.S. patents 4,420,535 and 3,953,649, and German published application DE-A 39 09 483).

Summary of the Invention

It is an object of the invention to provide a topcoated wire which has a high resistance to partial discharges and makes possible windings in which no uncontrolled hollows occur between the stacks of conductors or between neighboring windings of a coil.

This is achieved by an electrical conductor with rectangular or square cross-section said conductor having an electrically insulating layer on all sides of the

conductor, and further comprising a topcoat lacquer film provided on less than all sides of said conductor, preferably only one side or two opposite sides.

The object of the invention is further achieved by a process for the production of such an electrical conductor.

In addition to the advantages resulting directly from the definition of the problem, a further advantage results in that there is a significant savings in topcoat lacquer as well as energy.

Brief Description of the Drawings

The invention will be described in more detail with reference to the exemplary embodiments shown schematically in Figs. 1 to 3, wherein:

Fig. 1 shows a section through an electrical conductor;

Fig. 2 shows a section through a small area of a twisted conductor; and

Fig. 3 shows a side view of a manufacturing device.

Detailed Description of the Invention

In Fig. 1, a flat metallic conductor 1, preferably made of copper, is depicted having a coating 2 of an insulating lacquer on all sides. The insulating lacquer can, for example, consist of a polyester imide, a polyamide imide, or a similar material. The thickness of the coating 2 is between 10 and 100 μm and can be applied in several layers. The individual layers can also consist of different materials.

The dimensions of the conductor are, e.g., 3.0–12.5 mm in width and 1.1–3.3 mm in height.

One layer 3 of a topcoat lacquer is applied to each of the long flat faces of the conductor 1 provided with the coating 2. The short faces are free of topcoat lacquer. The thickness of the layers 3 is between 40 and 80 μm.

The topcoat lacquer preferably consists of a copolyamide with a cross-linking agent, which causes a chemical cross-linking of the thermoplastic copolyamide under the influence of heat, added to it. The cross-linking agent contains a multivalent alcohol, a polyisocyanate, and a polyol. The layer 3 made of topcoat lacquer can also consist of several individual layers.

The topcoat lacquer can also consist of an epoxy resin, which is also preferably cross-linked.

Fig. 2 shows a small section from a so-called twisted conductor. After the coating 2 and the topcoat lacquer have been applied, several of these single conductors are made into a twisted conductor. A process for the production of twisted conductors is known from EP-A 0 408 832. After twisting, the twisted conductor is warmed to approximately 120-130°C. At this temperature, the single conductors stick together at their surfaces, which are coated with topcoat lacquer. A narrow gap 4 thereby arises between the individual stacks of the single conductors, as the short side faces of the single conductors are free of topcoat lacquer. If this type of twisted conductor is used for coils for oil-cooled transformers, the transformer oil can permeate the gap 4, so that no uncontrolled hollows arise which could lead to destruction of the transformer. The topcoat lacquer film between the single conductors of a conductor stack in the twisted conductor also produces a solid bond between the single conductors. The resoftening temperature of the thermoplastic copolyamide is significantly increased by cross-linking and can be up to 200°C.

The production of a conductor 1 as it is depicted in Fig. 1 will be described with reference to Fig. 3.

The conductor 1 provided with the insulating lacquer coating 2 is drawn off from a supply spool 5 and coated on its upper side with topcoat lacquer by means of an applicator roll 6. The applicator roll 6 is saturated by a reservoir 7 containing fluid topcoat lacquer. A second applicator roll 8 coats the lower side of the conductor 1, 2 with topcoat lacquer. The applicator roll 8 rotates in a bath 9 of topcoat lacquer.

The two layers of topcoat lacquer 3 are then dried in a drying oven 10 at approximately 300°C. The finished conductor is then wound onto a supply spool 11.

The topcoat lacquer is cross-linked after the single conductors are made into the twisted conductor, preferably after the twisted conductor is wound into a transformer coil.

The conductor can also be coated with topcoat lacquer in a vertical pass.

What Is Claimed is

1. An electrical conductor with rectangular or square cross-section said conductor having an electrically insulating layer on all sides of the conductor, and further comprising a topcoat lacquer film provided on less than all sides of said conductor.

2. An electrical conductor according to claim 1, wherein said topcoat lacquer film is only applied to one side of said conductor.

3. An electrical conductor according to claim 1, wherein said topcoat lacquer film is applied to only two sides of said conductor, which are opposite one another.

4. An electrical conductor according to claim 1, in which the electrical conductor has a rectangular cross-section with short and long sides, wherein only the long sides of the rectangle are coated with topcoat lacquer.

5. An electrical conductor according to claim 1, wherein the topcoat lacquer is a resin based on epoxy, a polyester, a polyester imide, or a polyamide.

6. An electrical conductor according to claim 1, wherein the topcoat lacquer contains a cross-linking agent.

7. A process for the production of an electrical conductor with a quadrilateral cross-section and a plurality of surfaces, said method comprising the steps of coating a surface of the conductor with a lacquer film and subsequently applying a layer of topcoat lacquer to the lacquer film, wherein the applying step comprises applying a layer of topcoat lacquer to less than all of said surfaces.

8. A process according to claim 7, wherein said applying step comprises applying a layer of topcoat lacquer to only one surface of the conductor.

9. A process according to claim 7, wherein said applying step comprises applying a layer of topcoat lacquer to only two surfaces of the conductor, which are opposite one another.

10. A process according to claim 7, wherein said cross-section is rectangular and said topcoat lacquer is applied to the long sides of the rectangle.

11. A process according to claim 7, wherein the topcoat lacquer is applied by means of rotating rollers.

12. A process according to claim 7, wherein said topcoat lacquer comprises a reactive prepolymer.

13. A process according to claim 12, wherein said prepolymer is a prepolymer which hardens due to cross-linking.

14. A twisted conductor for one of a coil or an oil-cooled transformer, said conductor comprising an electrical conductor with rectangular or square cross-section, said conductor having an electrically insulating layer on all sides of the conductor, and further comprising a topcoat lacquer film provided on less than all sides of said conductor.

15. A twisted conductor for one of a coil or an oil-cooled transformer, said conductor comprising an electrical conductor with a quadrilateral cross-section and a plurality of surfaces, said conductor made by a process comprising the steps of coating a surface of the conductor with a lacquer film and subsequently applying a

layer of topcoat lacquer to the lacquer film, wherein the applying step comprises applying a layer of topcoat lacquer to less than all of said surfaces.

ABSTRACT

An electrical conductor (1) with a rectangular or square cross-section has a first electrically insulating film (2) surrounding the conductor on all sides and a second topcoat lacquer film (3) provided on the first layer. The topcoat lacquer film (3) is only applied to one surface, or at most to two surfaces opposite to one another.

Fig. 1

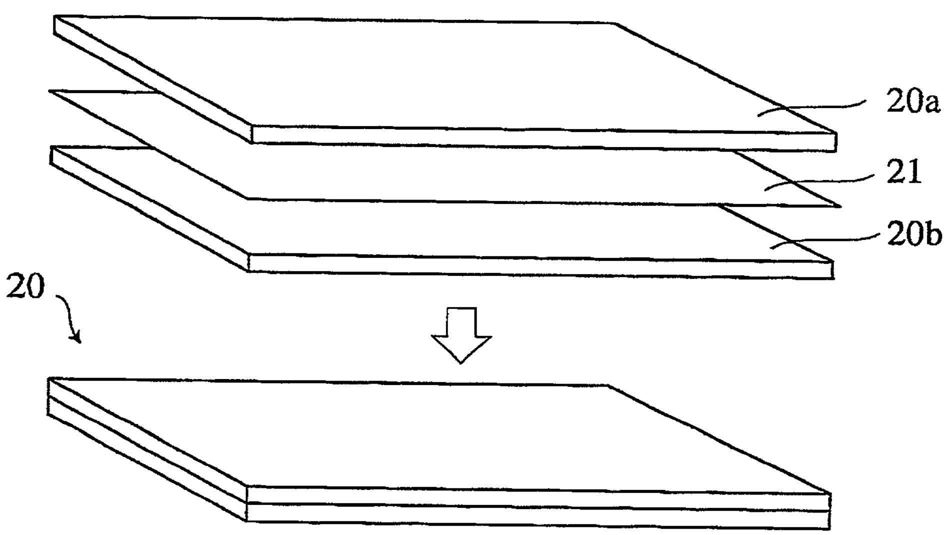
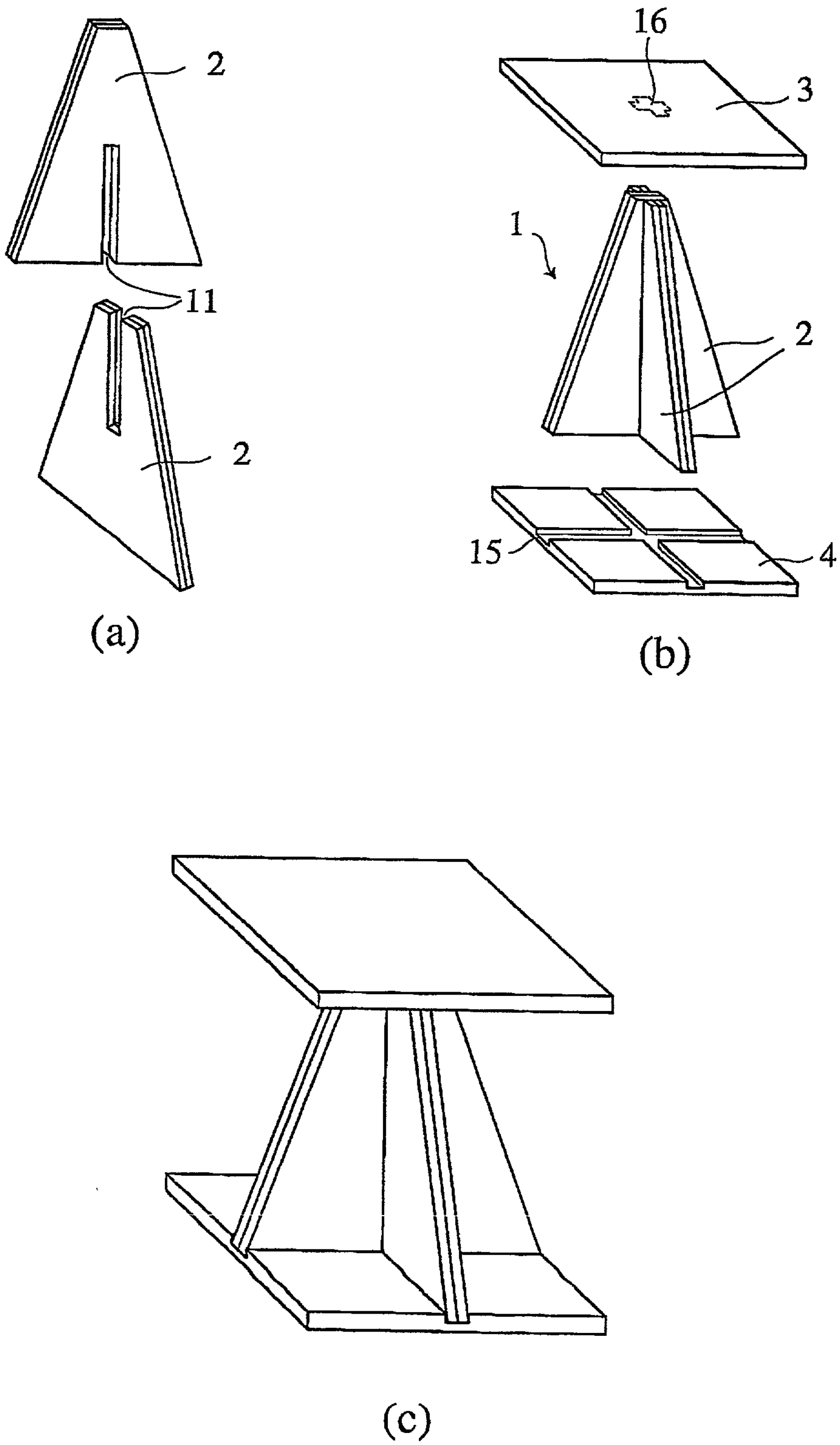


Fig. 2



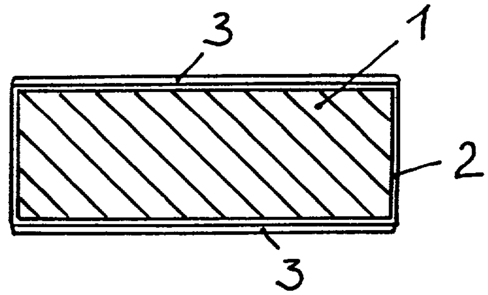


Fig 1

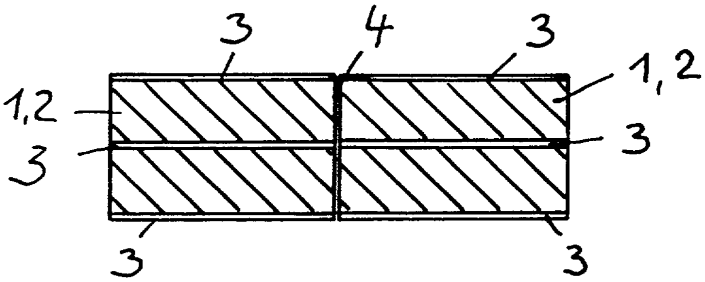


Fig.2

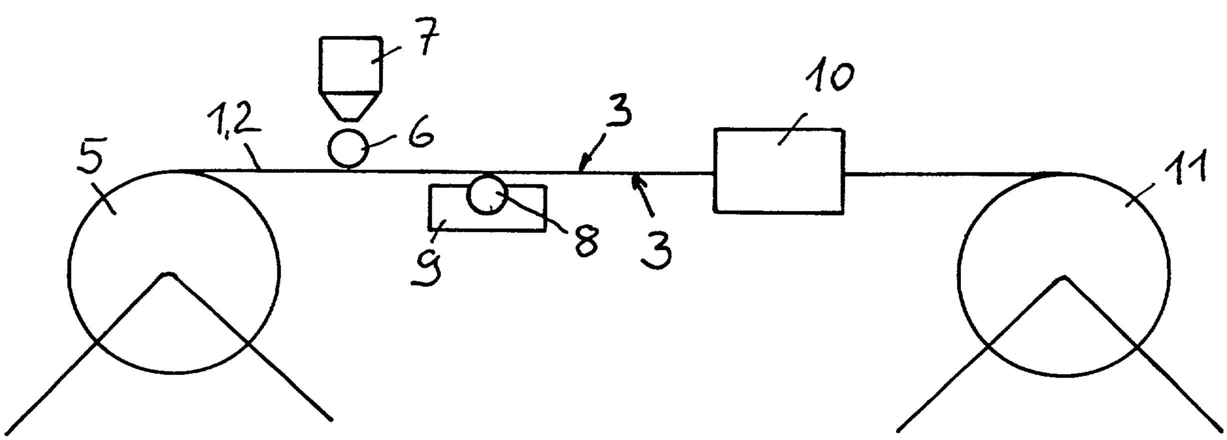


Fig 3

Fig. 3

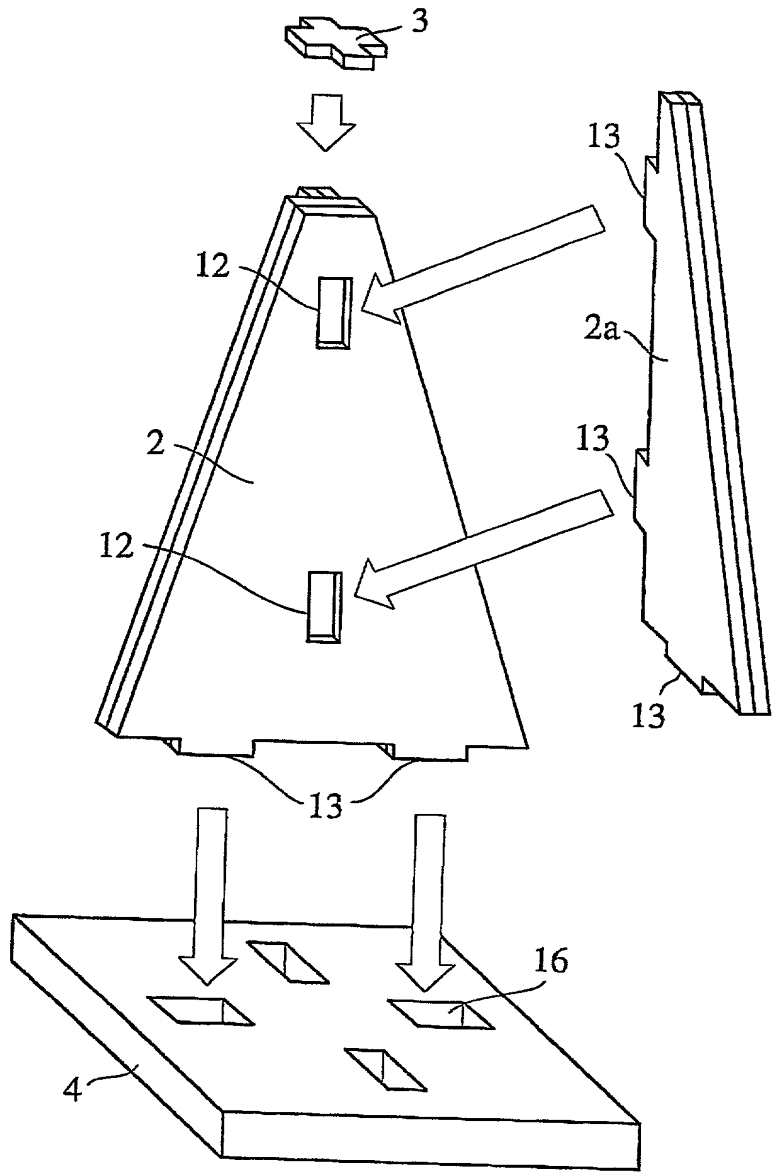


Fig. 4

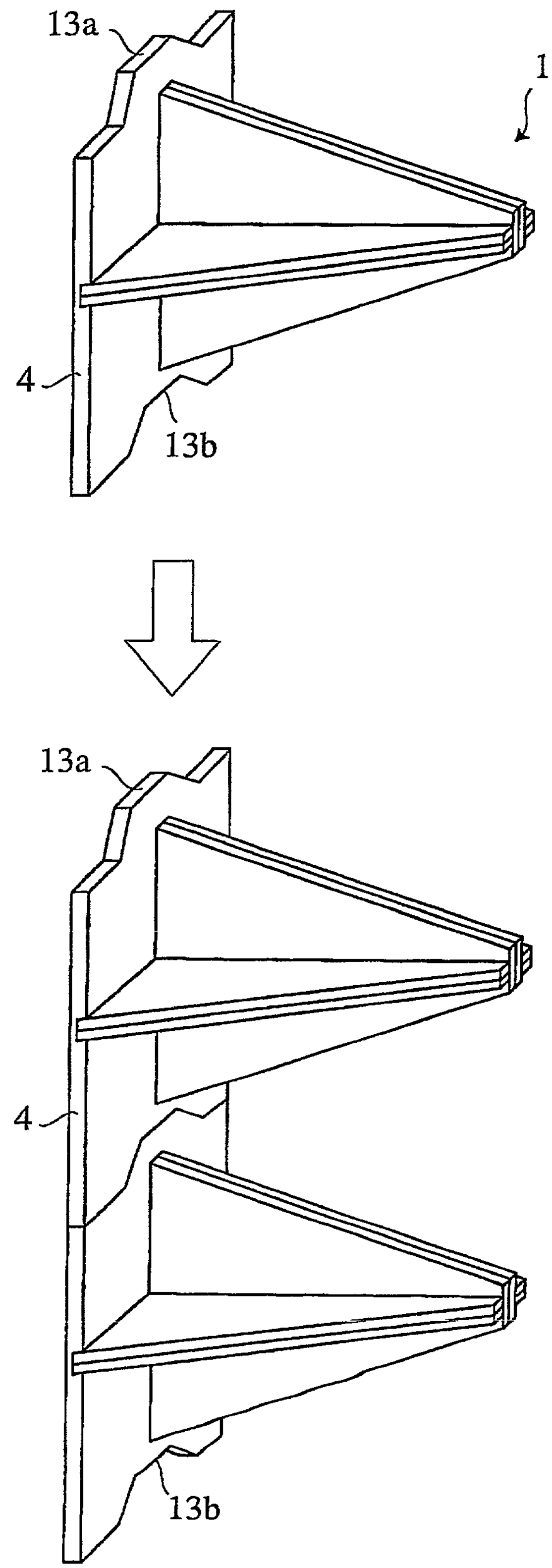
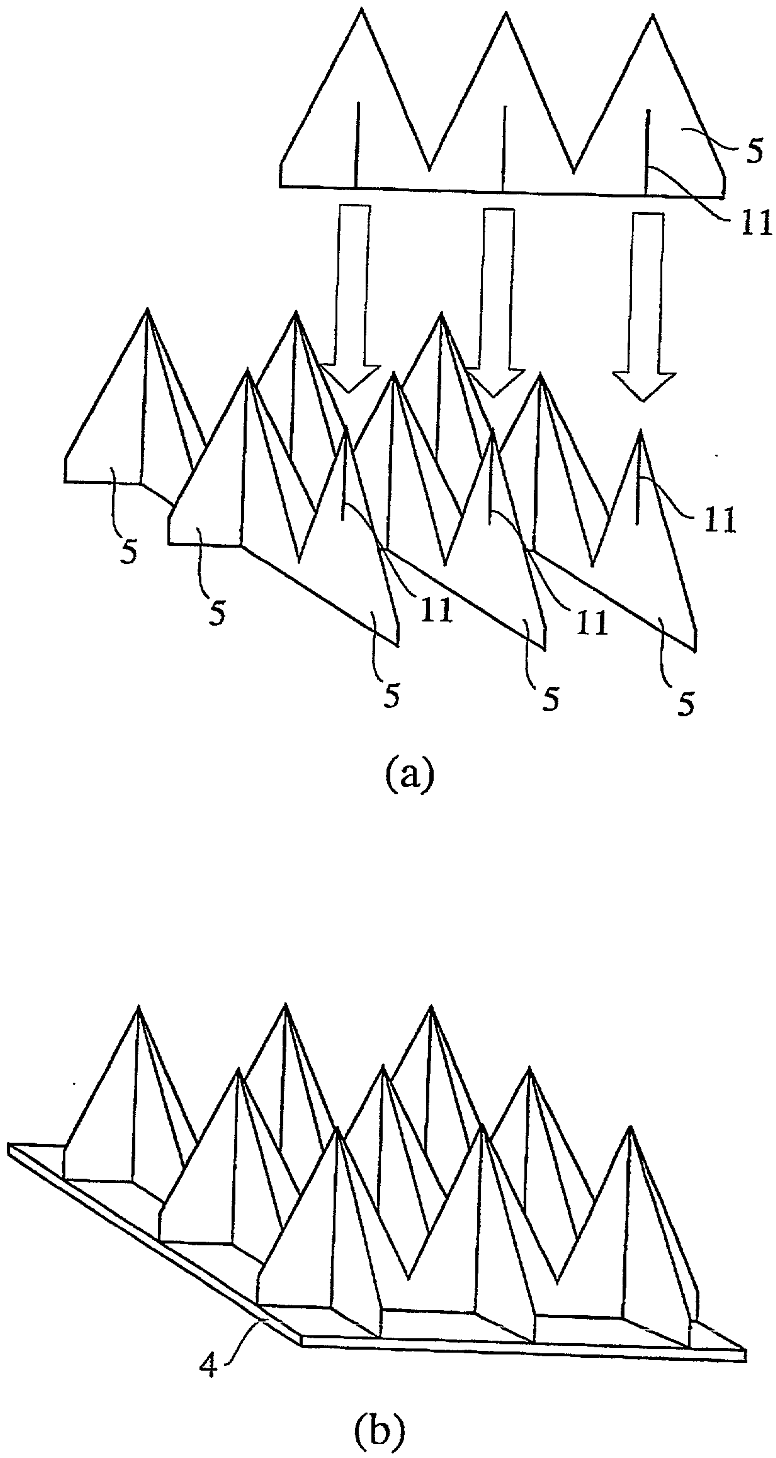


Fig. 5



(a)

(b)

Fig. 6

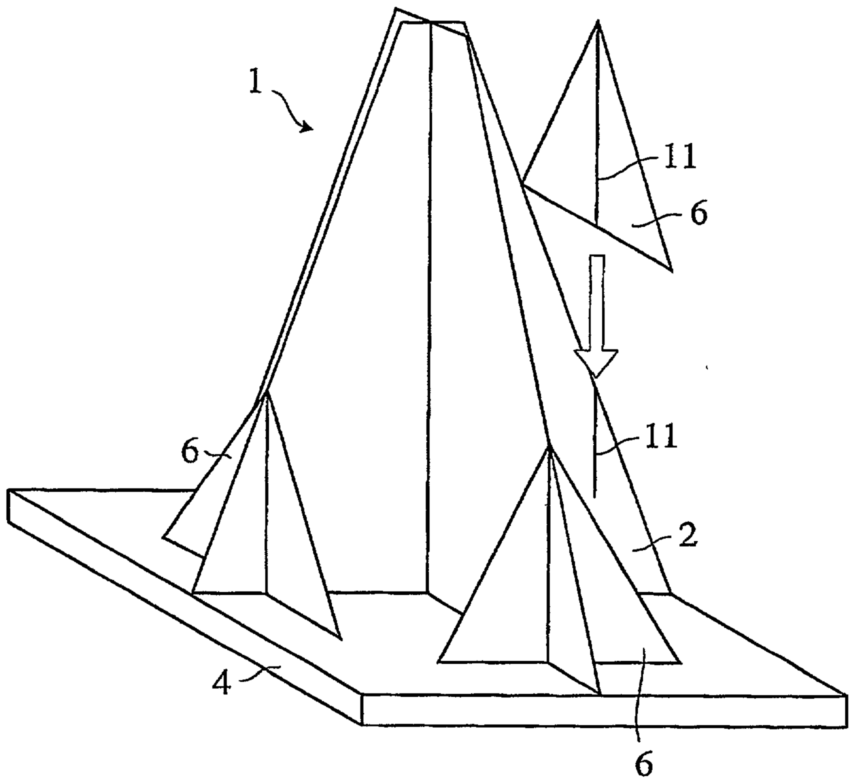


Fig. 7

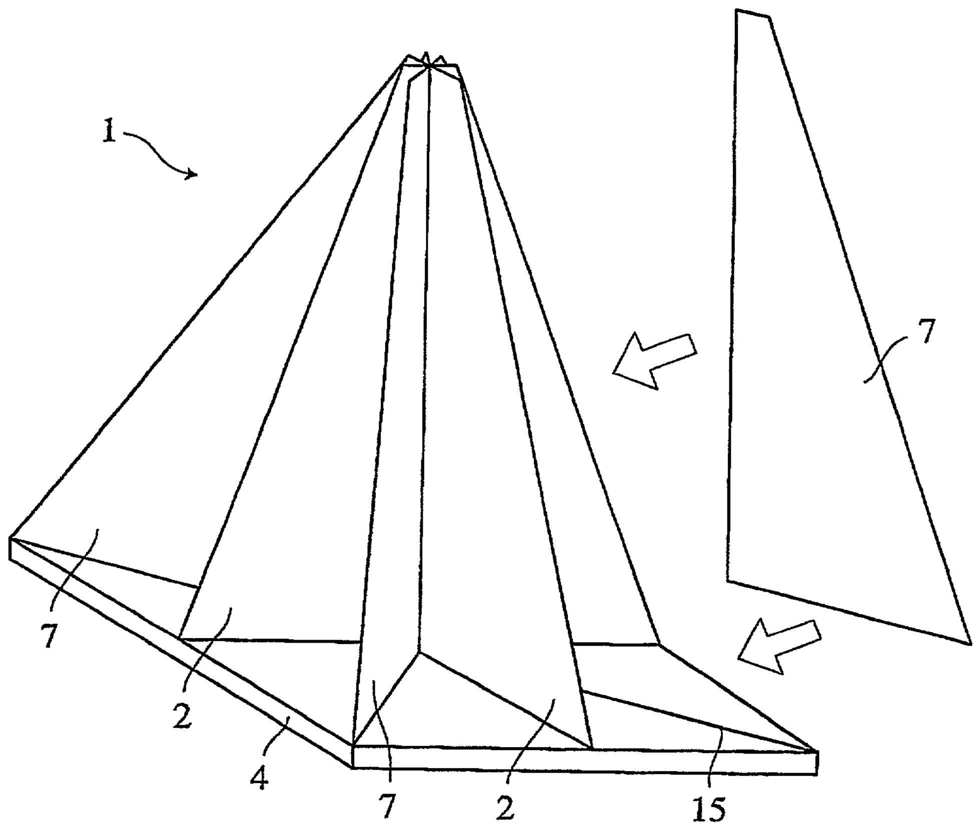


Fig. 8

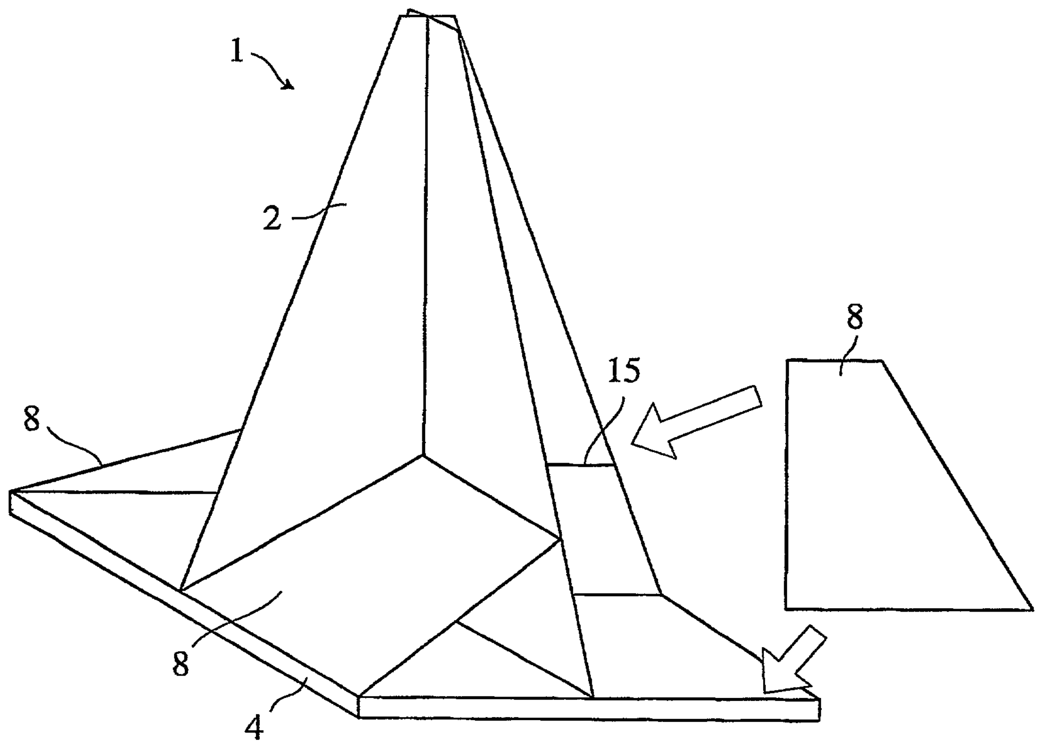
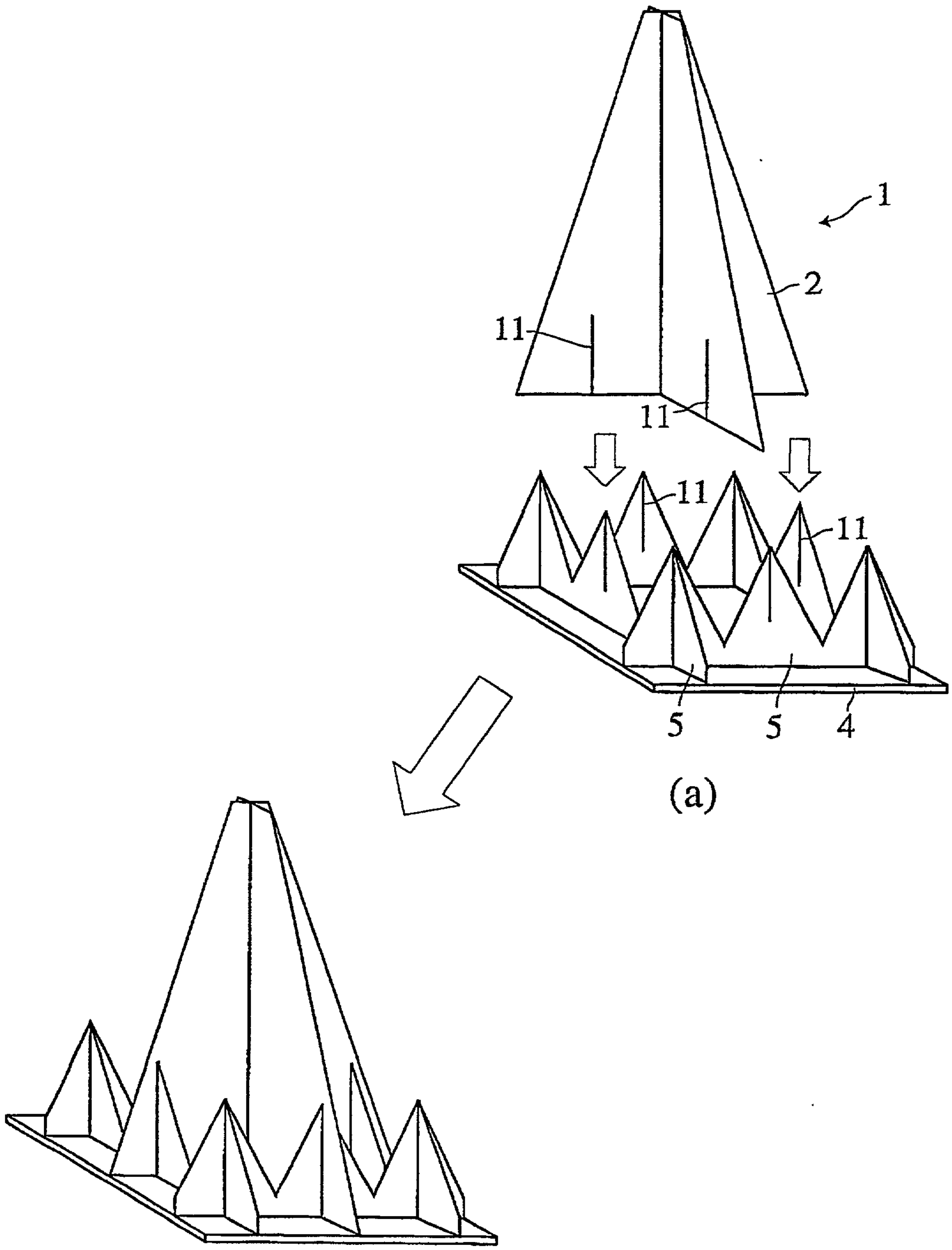


Fig. 9



(a)

(b)

Fig. 10

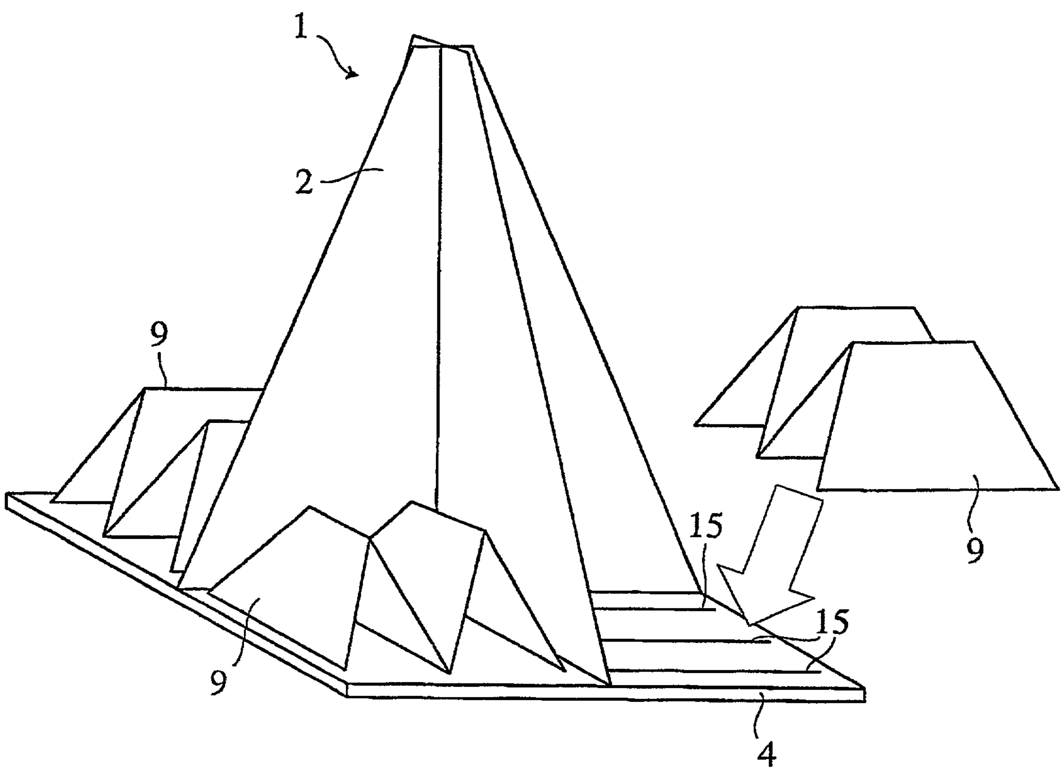


Fig. 11

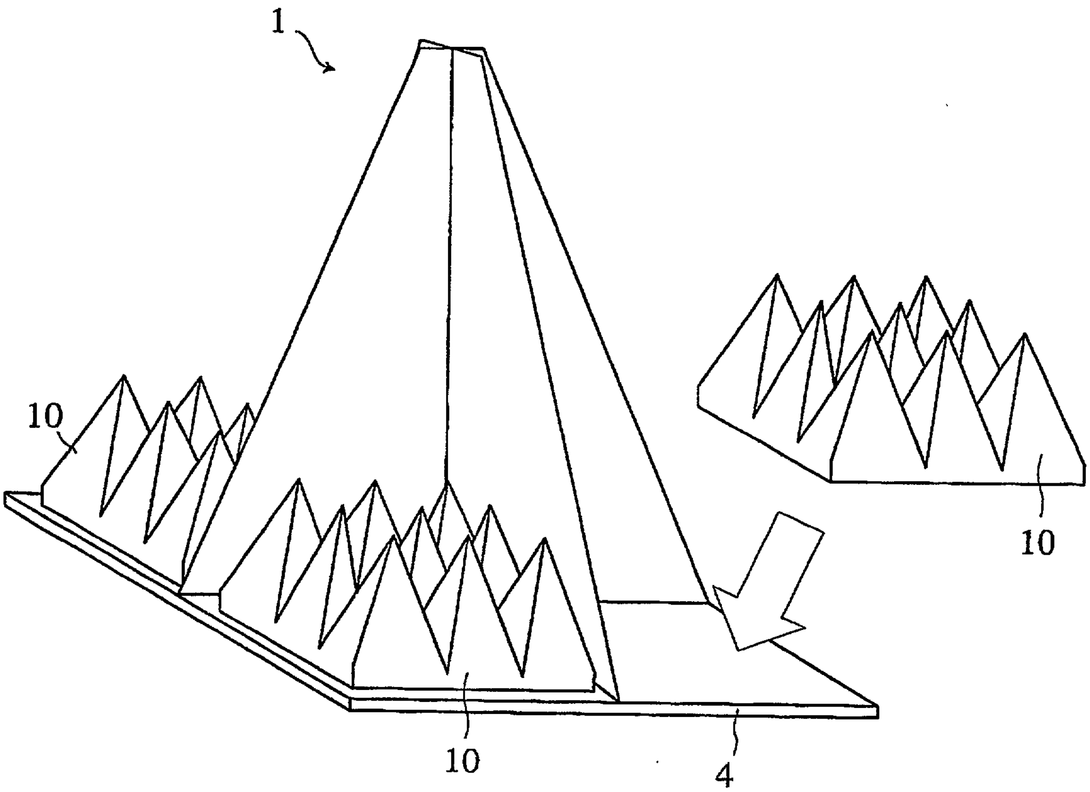
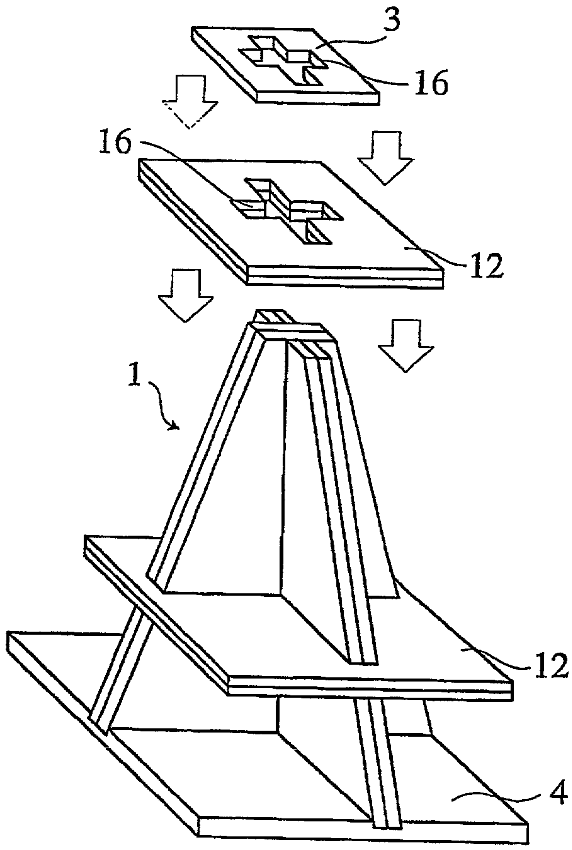
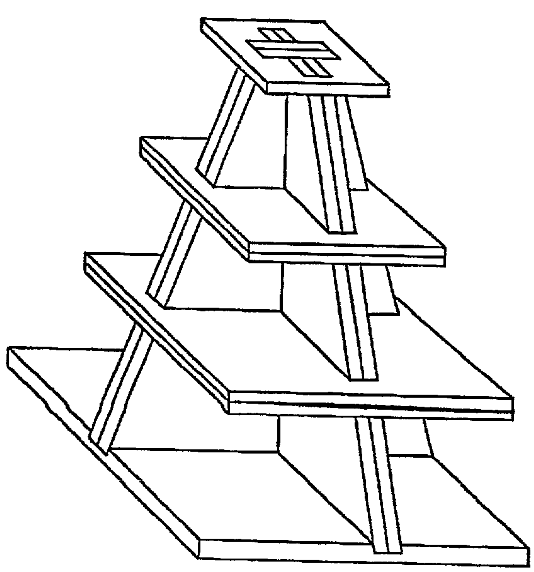


Fig. 12



(a)



(b)

ATTORNEY DOCKET NO. ____________________

Combined Declaration for Patent Application and Power of Attorney

As a below named inventor, I hereby declare that:
My residence, post office address and citizenship are as stated below next to my name; and that I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Electromagnetic Wave Absorber

the specification of which (check one)

[x] is attached hereto;

[ ] was filed in the United States under 35 U.S.C. §111 on____________, as USSN ____________*; or was/will be filed in the U.S. under 35 U.S.C. §371 by entry into the U.S. national stage of an international (PCT) application, PCT/____________, filed ____________, entry requested on ____________*; national stage application received USSN ____________*; §371/§102(e) date ____________* (*if known),

and was amended on ______________________________(if applicable)

(include dates of amendments under PCT Art. 19 and 34 if PCT)

I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above; and I acknowledge the duty to disclose information which is material to the examination of this application in accordance with 37 C.F.R.§1.56(a).

I hereby claim foreign priority benefits under 35 U.S.C. §119, 365 of any prior foreign application(s) for patent or inventor' s certificate, or prior PCT application(s) designating a country other than the U.S., listed below with the "Yes" box checked and have also identified below any such application having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)

Application Number	**Country**	**Filing Date** (Day/Month/Year)	**Priority Claimed** *(yes or no)*
11-307200	Japan	28/10/1999	Yes

I hereby claim the benefit under 35 U.S.C. §120 of any prior United States Application(s) or prior PCT Application(s) designating the U.S. listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in such U.S. or PCT application in the manner provided by the first paragraph of 35 U.S.C. §112, I acknowledge the duty to disclose material information as defined in 37 C.F.R. §1.56(a) which occurred between the filing date of the prior application and the national filing date of this application:

ATTORNEY DOCKET NO. ____________________

Application Serial No.	Filing Date	**Status** *(patented, pending, abandoned)*

As a named inventor, I hereby appoint the following registered practioners to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

All of the practioners associated with Customer Number 001444

Direct all correspondence to the address associated with Customer Number 001444; i.e.,

BROWDY AND NEIMARK
624 Ninth Street, N.W.
Washington, D.C. 20001-5303
(202)628-5197

I hereby further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. §1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

FIRST INVENTOR

Full Name	**Signature**	**Date**
Toshikatsu HAYASHI	T. Hayashi	October 24, 2000
Residence		**Citizenship**
Saitama-ken, Japan		Japan
Post Office Address		
c/o Kabushiki Kaisha Riken, Kumagaya Plant of 14-1 Suehiro 4-chome, Kumagaya-shi, Saitama-ken, Japan		

SECOND INVENTOR

Full Name	**Signature**	**Date**
Yasushi SAKAI	Y. Sakai	October 24, 2000
Residence		**Citizenship**
Saitama-ken, Japan		Japan
Post Office Address		
c/o Kabushiki Kaisha Riken, Kumagaya Plant of 14-1 Suehiro 4-chome, Kumagaya-shi, Saitama-ken, Japan		